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Improvement of the Quality of Input Data and its Effect in the Uncertainty of a Noise Map

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ABSTRACT

The influence of applying European default values to the making of a noise map was evaluated in a typical environment like Palma de Mallorca. These default values were compared with measured noise levels and the model was validated or rejected according to the deviations. After an unacceptable initial result, quantification of improvements to the process has been performed. This analysis demonstrates that the use of noise source default data in the absence of specific data can generate deviations in excess of more than 9 dB. Consequently, additional data gathered were of higher quality and were collected using different techniques.

Different methodologies were also examined for collecting model input data that would be of the highest possible quality, by analysing the improvement generated in the reduction in the uncertainty of the final result of the noise map.

Improvements to the process consisted of a developing a new traffic network with current data, obtaining more experimental data with a greater geographical sampling of traffic, implementing a new road categorization system and using alternative techniques to obtain the composition and speed of traffic.

1. INTRODUCTION

Carrying out a noise map by means of simulation techniques and also validated with experimental measurements implies several parameters affecting the final uncertainty.

The main sources of uncertainty of noise maps could be classified in the following groups: Experimental measurements, Calculation method, Calculation engine (software) and Acoustic model creation [1].

In this paper the process of improving the quality of data related to the Acoustic model creation is quantified; with preciseness, only traffic model was improved.

The inhabited areas of Palma de Mallorca (Spain) were chosen as the study area, excluding any areas, which, although within the municipal boundaries, were lacking in high population density or which, due to the habitual use of the ground, were not particularly noise-sensitive. In the study area road and rail traffic were included as noise sources as there was no industry of note in the area. However, this research will deal exclusively with the uncertainty of road-traffic noise simulation outcomes.

2. INITIAL MODEL (PHASE 1)

A first step with low quality and default data was simulated. The vast majority of road sections were modelled using a main road with one lane in each direction. Traffic data were collected using macro-simulation techniques [2]. Supplementary data for the year 2005 was supplied for time distribution by 32 spirals at 17 crossroads, distributed throughout the city. The only available data were the Daily Mean Intensity (DMI), which means that estimates had to be made to take account of the necessary essential data [1]. In the absence of a large amount of data and the detail required to construct the noise model, a series of measures were taken to obtain the data and/or for the application of default values.

Assigning road types was done according to DMI data, and adjusting it to different recommendations [1, 3], appearing to match the circumstances actually examined: “A” (Speedway), “B” (Highway) and “C” (Urban road). The traffic model provided only considered the main thoroughfares. The other streets were included in the noise model with DMI default values [1]. Due to the main thoroughfares having been assigned DMI values, values only had to be set for type “C” sections: urban road.

Related the time distribution, since calculations roughly coincided with the recommended default values [1], these values were used (70%, 20% and 10% for day, evening and night periods respectively).

Since no data whatsoever were available for vehicle speed, estimates of effective speed were made according to road type, using the speed limits [1].

The distribution of light and heavy vehicles was based on road type, and adapted to internationally recommended criteria [1]. Since no data were available in this respect, the most conservative default values were used, starting out from the hypothesis that these figures would match the established road type.

3. MEASUREMENT CAMPAIGN (PHASE 1)

A measuring campaign was carried out in the months of July and August 2006 at 4 representative points of the set road categories [4]. Those control points were chosen taken into account the traffic data available for each road category, after the road categorization establishment [3]. Measurements were taken for 30 days, which means that measurement uncertainty was considerably reduced by having a more than representative sample [5]. All the measurements were carried out under selected meteorological conditions which are reproducible and correspond to quite stable sound propagation conditions, thus during adverse meteorological conditions as rain or high wind speed the measurement data were rejected [6].

4. VALIDATING THE ROAD TRAFFIC MODEL (PHASE 1)

When measured and simulated values were compared some very large differences were found, with a maximum deviation of 9.1 dB; a mean deviation 7.0 dB and a minimum deviation of 4.0 dB above the measured values, giving an uncertainty value of ±8.7 dB with a cover factor k=2 and confidence level of 95.45% [7].
As the calibration option was rejected, due to the very high deviations, it was decided to make a meticulous analysis of the simulation model and find the most sensitive and least accurate data, with the purpose of performing a new input data collection for the noise model that would produce a noticeable improvement in its quality [8].

5. IMPROVING INPUT DATA FOR THE ROAD TRAFFIC MODEL (PHASE 2)

After examining the errors and gaps in the data entered into the road traffic model, it was found that the least accurate data were the most sensitive: data referring to noise source [9]. It was therefore decided to improve this data.

The *Department of Mobility* provided a new traffic model with data updated to 2007 and consistent with the spot measurements of the spirals distributed around the city. Duplicated sections and existing errors in the previous traffic model were cleaned up. In addition, the main thoroughfares along the main Avenues were given additional lanes/axis for each direction of flow. A new road classification (up to 4) was made that was based on Bus Routes, Main Maps, Aerial Photographs, the DMI of the new traffic model and the Department of Mobility’s knowledge of the road network.

To determine the time distribution of vehicles, data updated to 2007 were available from over 100 spirals distributed around the city, representing all the categories previously defined.

In order to determine the data needed for traffic distribution it was decided to view the camera screens of the Department of Mobility on the major thoroughfares, as it was those that carried the highest percentage of heavy vehicles. 6 time zones were established that were representative of the time periods being examined (day, evening and night).

The method to obtain speed data was based on GPS techniques in a *floating vehicle* for reasons of cost, time and data quality [10, 11]. Measurements were taken for 6 days during the three time periods (day, evening and night) along several roads from all the previously defined noise categories.

6. VALIDATING THE NEW ROAD TRAFFIC MODEL (PHASE 2)

In order to carry out the validation campaign for the new traffic model with the current data, 4 measuring stations were installed for two weeks between June and July 2008. In addition, samples for shorter periods were taken at up to a total of 11 other points, distributed on all the road categories, close to the real traffic data control points using spirals.

Making a calculation of expanded uncertainty, a value of ±1.1 dB was found [12], with a cover factor k=2 and confidence level of 95.45% [7].

With the construction of the new traffic model, a standard deviation of ±2.1 dB was found between the measured and simulated values, with expanded uncertainty being ± 4.1 dB for a confidence level of 95.45%. Although the values of uncertainty calculated for the new traffic model were more than acceptable [13], systematic deviations were found between the measured and simulated measurements depending on the period of study. For this reason the model was calibrated, correcting the mean systematic error in each study period (day, evening and night) [8], which considerably increased the quality of the final result.

7. CONCLUSIONS

The improvement of the noise map creation process came solely and exclusively from the use of better traffic noise source data, while the same quality and processing of data related to acoustic barriers and cartography was maintained. Of special relevance is having found the input data for effective vehicle speed by the technique used and the methodology for finding the contributions of vehicles according to weight, since this is one of the most influential input data [1]. As a summary, Table 1 shows the two models: the approximate uncertainty estimated by the GPG of each single input data [1, 13] and the actual calculated expanded uncertainty.

Table 1. Input data quality and related uncertainties.

	Initial model (phase1)		**Final model (phase2)**	
Input data	**Data quality**	**Uncertainty (GPG)**	**Data quality**	**Uncertainty (GPG)**
Traffic flow data	Initial data (2005)	--	Final data (2007)	--
Road type categorization	3 categories	--	4/5 categories	--
Traffic flow period distribution	Default values	1 dB	Real values	< 0.5 dB
Stretches with no data	Default values	4 dB (local)	Similar categories approximation	2 dB (local)
Light/heavy	Default values	2 dB	Camera recordings data	< 0.5 dB
Road axis digitalization	1 single axis	3 – 5 dB	2 axis (main roads)	1 – 3 dB (local)
Speed	Speed limit data	2 dB	Floating vehicle data	< 0.5 dB
U_{total} determined	**8.7 dB**		**4.1 dB (before calibration)** **1.7 dB (after calibration)**	

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